Star Passages Through the Oort Cloud

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Random passing stars regularly penetrate the Oort cloud, resulting in major perturbations to the orbits of comets there. The dynamical effects include the hyperbolic ejection of comets to interstellar spare, the initiation of cometary showers into the planetary region, and a general pumping of energy and angular momentum into the cometary orbits, The detailed effects of individual star passages are investigated with a Monte Carlo simulation model for a range of stellar masses and velocities. For example, a one solar mass star passing 104 AU from the Sun, an event which occurs about once every 50 Myr, at a velocity of 20 km sec^{-1} will eject 1.0×10^{-4} of the Oort cloud population to interstellar space with a mean hyperbolic velocity of 0.45 km sec^{-1}. An additional 1.3×10^{-5} of the comets will be perturbed to aphelia beyond the Sun's sphere of influence, and will likely escape. At the same time, a comet shower o - 1.3×10^{-5} of the Oort cloud population is perturbed into Earth-crossing orbits. The flux of comets into the planetary region peaks approximately 10^5 years after the slar'slime of closest approach to the Sun, and remains high for ~0.4 Myr. Most of the ejected comets are positioned along a narrow "tunnel" ofradius- 500 AU, centered on the star's essentially rectilinear path. A similar, one solar mass star passage at 3×10^3 AU, a 500" Myr event, ejects 1.7×10^{-3} of the population with a mean velocity of 0.53 km sec^{-1}, and sends in an 1 Earth-crossing shower of -1.2×10^{-4} of the total cloud population. Current estimates for the population of the Oort cloud arc on the order of 10^{13} Comets.

1 Estimates of the fract ion of comets lost to each of the possible end-states as a function of stellar mass and velocity will be presented. 1 n addit ion, the total losses over the history of the solar system will be estimated.

11 is also worthwhile to ask whether the flux of comets into the planetary region is currently enhanced due to a recent stellar passage through the Oort cloud. Cometary showers have been invoked to try and explain the enhanced cratering rate currently estimated for the 1 Earth over the past 250 Myr, which is about twice that estimated for the Moon over the past 3 Gyr. Simulation of the orbit element distributions for cometary showers show that there is not a strong enough signature in either the inclination, argument of perihel ion, or ascending node to be able to discriminate a shower from the currently observed distributions for the long-period comets. However, the $1/a_o$ distribution for the lcmg,-period comets shows no evidence of a perturbation of the inner Oort cloud, as would be expected for a major cometary shower. This latter test rules out any possibility of a cometary shower within at least the last 10^6 years.

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